DESCRIPTION

DIAGNOSTIC ULTRASOUND SYSTEM AND

METHOD FOR DISPLAYING INFORMATION ON DISTORTION OF

5   BIOLOGICAL TISSUE IN ULTRASONIC IMAGE

Technical Field

The present invention relates to a diagnostic
ultrasound system which time-sequentially obtains ultrasonic
10   images (ultrasonic cross-section images) while varying of
pressure applied to a biological body (subject) using a
probe, and which diagnoses hardness or softness of a
biological tissue by utilizing a difference between
ultrasonic images.

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Background Art

In conventional diagnostic ultrasound systems, as
described in Japanese Patent No. 3194947 and U.S. Patent No.
5143070, when an examining physician such as a paramedic
20   applies extraneous force to a body surface of a region-of-
interest in a subject using a probe, a difference between
ultrasonic cross-section images of different frames is
produced in order to measure a displacement caused by
applying the extraneous force. The conventional arts make
25   it possible to diagnoses hardness or softness of each

biological tissue in the region-of-interest.

However, the above patent documents merely describe displaying a contour image of distortion and Young's modules values. The conventional diagnostic ultrasound systems

5   cannot cope with the need for time-sequentially acquiring ultrasonic images while varying the pressure applied a body surface by giving force to a probe, and producing a difference between ultrasonic images so as to visualize the hardness or softness of a biological tissue.

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Disclosure of Invention

The foregoing drawback is overcome by a diagnostic ultrasound system including: a probe for ultrasonic measurement by bringing said the probe into contact with a

15   subject in a first state; a first image production means for producing a first image of the subject according to information received from the probe; an image display means for displaying the first image produced by the first image production means; a means for setting at least one piece of

20   reference information on the first image displayed by the image display means; a second image production means for producing a second image of the subject according to information measured by bringing the probe into contact with the subject in a second state different from the first

25   state; a variation operation means for calculating a change

of the reference information, which is set on the first
image by the setting means, into a counterpart visualized in
the second image; a distortion operation means for
calculating distortion information on a desired region-of-

5 interest delineated in the second image according to the
change calculated by the variation operation means; and a
display control means for controlling the display of
distortion information, which is calculated by the
distortion operation means, on the image display means.

10 Moreover, aside from the foregoing hardware
configuration, a computer system included in the diagnostic
ultrasound system or a general-purpose computer may
implement a method of displaying distortion information on a
biological tissue observed in an ultrasonic image; the

15 method including a step for time-sequentially storing
displacements of a biological tissue in a memory means, a
step for time-sequentially reading the displacements from
the memory, a step for displaying distortion information on
a biological tissue so as to the displacements can be

20 relatively observed.

Brief Description of the Drawings
Fig. 1 shows a schematic block diagram for explaining a
diagnostic ultrasound system in accordance with an

25 embodiment of the present invention;

Fig. 2 shows a schematic block diagram for explaining a feature point sampling unit included in the embodiment;

Fig. 3 shows a schematic drawing for explaining an image after filtered according to the embodiment;

5 Fig. 4 shows a schematic diagram for explaining a weighting unit included in the embodiment;

Fig. 5 shows a schematic drawing for explaining an action of a clustering unit included in the embodiment;

Fig. 6 shows a schematic drawing for explaining an 10 action of correlation pre-processing unit included in the embodiment;

Fig. 7 shows a schematic drawing for explaining an action of a counterpart calculation block included in the embodiment;

15 Fig. 8 shows a schematic block diagram for explaining a displacement operation unit included in the embodiment;

Fig. 9 shows a schematic drawing for explaining an action of a first filter included in the embodiment;

Fig. 10 shows a schematic drawing for explaining an 20 action of the first filter included in the embodiment;

Fig. 11 shows positional relationships between a region-of-interest in a subject and a probe attained before and after a pressure load is applied according to the embodiment;

25 Fig. 12 shows graphs concerned in the relationships of

image display parameters to time;

Fig. 13 shows an example of the display on a display device;

Fig. 14 shows another example of the display on the
5   display device different from that shown in Fig. 13; and

Fig. 15 shows a flowchart describing display of distortion information.

Best Mode for Carrying Out the Invention

10   Referring to the appended drawings, an embodiment of the present invention will be described below.

Fig. 1 shows a schematic block diagram for explaining a diagnostic ultrasound system in accordance with an embodiment of the present invention.

15   The diagnostic ultrasound system in accordance with the embodiment includes: a probe (ultrasonic probe) 1; an ultrasonic-wave transmitting/receiving unit 2 electrically connected to the probe 1; a complex cine memory 3 electrically connected to the ultrasonic-wave

20   transmitting/receiving unit 2; a frame memory 4 electrically connected to the complex cine memory 3; a display unit 5 electrically connected to the frame memory 4; a feature point (reference information) sampling unit 6 electrically connected to each of the complex cine memory 3 and frame

25   memory 4; a displacement operation unit 7 electrically

connected to each of the complex cine memory 3, frame memory 4, and feature point sampling unit 6, and a setting unit 30 electrically connected to the display unit 5.

An operation means has the capabilities of the complex
5   cine memory 3, frame memory 4, feature point sampling unit 6, and displacement operation unit 7.

The probe 1 is a known probe which transmits or receives ultrasonic waves to or from a subject so that mechanically or electronically beam scan is carried out.
10   The probe 1 includes one or more transducers (transducer elements) which serve as a source of ultrasonic waves and receive echoes reflected from a subject in a biological body.

The ultrasonic-wave transmitting/receiving unit 2 drives the probe 1 for generation of ultrasonic waves, and
15   handles electric signals (echo signals) outputted from the transducer elements according to reflected echoes. The ultrasonic-wave transmitting/receiving unit 2 includes a known transmission pulser and transmission delay circuit for producing an ultrasonic beam to be transmitted from the
20   probe 1 to a subject, a reception amplifier which amplifies echo signals received by the each transducers arrayed in the probe 1, and a phasing/adding circuit which arranges and adds the phase of the amplified input reflective echo signal.

In the complex cine memory 3, echo signals which are
25   phased by the ultrasonic-wave transmitting/receiving unit 2

are time-sequentially stored as pieces of frame information representing a plurality of frames in the form of complex numbers or absolute values and phase angles.

The frame memory 4 produced image data by storing the frame information received from the complex cine memory 3 every scanning line according to ultrasonic beam. The frame memory 4 includes an affine transformation circuit which transforms scanning lines according to ultrasonic beam into scanning lines on a TV monitor, an image data memory, and an overlay circuit which displays color information, character string information, and graphic information on the display unit 5 while superposing them on one another.

The display unit 5 display an image according to a signal outputted from the frame memory 4. The display unit 5 has, for example, a TV monitor which receives a television signal representing a B-mode image (cross-section image) and on which the cross-section image is displayed.

The feature point sampling unit 6 extracts a feature point which copes with time-sequential data (time-series cross-section image) stored in the complex cine memory 3 and a pre-displacement (initial) cross-section image produced by the displacement operation unit and stored in a memory. Herein, the pre-displacement image is, as shown in Fig. 11A, an image based on echo signals acquired when the distance of a feature point or a region-of-interest, which is located at

the deepest position relative to the vicinity of the probe,
from the vicinity of the probe (macro distance) is the
largest. As shown in Fig. 11A, before the probe 1 is
pressed against a subject, a biological tissue and a
5   plurality of local region-of-interest (ROI#1 and ROI#2) do
not change.

    Meanwhile, as shown in Fig. 11B, a post-displacement
image based on echo signals acquired when the macro distance
of the region-of-interest, which is located at the deepest
10 position, from the probe is the smallest. As shown in Fig.
11B, after the probe 1 is pressed against a subject, the
biological tissue and the a plurality of local region-of-
interest (ROI#1 and ROI#2) in the biological tissue are,
compared with those shown in Fig. 11A, deformed as if to
15 contract. The deformation is attributable to a micro
displacement made by a region-of-interest and a macro
displacement made by an entire biological body. The micro
displacement and macro displacement have a difference
indicated in Fig. 12. Fig. 12A shows the micro
20 displacements made by a region-of-interest with the passage
of time before and after pressure is applied to the body
surface. Fig. 12B shows the macro displacements made by the
biological body with the passage of time before and after
pressure is applied to the body surface. In other words,
25 the macro displacement and micro displacement show inherent

time-series changes before and after pressure is applied. The feature point sampling unit 6 will be detailed later.

The displacement operation unit 7 compares the feature point and counterpart, which are extracted by the feature
5 point sampling unit 6 before and after deformation, with each other, and calculates a variation of deformation made by a region-of-interest located at the feature point on the basis of the result of the comparison. The displacement operation unit 7 is designed to act according to whether a
10 feature point and its counterpart are detected by the feature point sampling unit 6. The displacement operation unit 7 includes: a means for deforming information stored in the complex cine memory so as to the feature point and counterpart will be agreed with each other; a means for
15 sequentially preserving a variation of movement derived from deformation (a variation of deformation) as a value of a displacement made by the region-of-interest; and a means for sequentially comparing the preserved displacement values with one another so as to calculate maximum and minimum
20 displacement values indicating displacements made by the region-of-interest. Moreover, since only the maximum and minimum displacement values indicating displacements made by the region-of-interest are calculated, an intermediate value of all displacement values indicating displacements made by
25 the region-of-interest or a displacement width by which the

region-of-interest is displaced in total may be calculated.
The displacement operation unit 7 will be detailed later.

The setting unit 30 is used to set arbitrary position
in a cross-section image of a subject displayed on the
5   display unit 5 as the position of a region-of-interest. The
setting unit 30 is also used to define various settings of
the diagnostic ultrasound system for production of images.

When the feature point and counterpart detected by the
feature point sampling unit 6 are represented by mutually
10   different coordinates, that is, the coordinates (positions)
representing the feature point and counterpart are different
from each other, the displacement operation unit 7 included
in the present embodiment acts as described below. First,
information read from the complex cine memory 3 is deformed
15   so at to the feature point and counterpart will be agreed
with each other. The deformed information and the
information that is not deformed are compared with each
other in order to calculate a variation of deformation as a
displacement value. Furthermore, maximum and minimum
20   displacement values are preserved. An image in which the
feature point is seen to have been displaced to a variation
indicated with the minimum displacement value is preserved
as an initial image, and an image in which the feature point
is seen to have been displaced to a variation indicated with
25   the maximum displacement value is preserved as a final image

produced after displacement. On the other hand, if the coordinates (positions) of the feature point and counterpart had no difference, or if the counterpart of the feature point ware not found, the displacement operation unit 7

5   would continue to preserve an initial image and a final image that are stored immediately previously.

A block may be interposed between the feature point sampling unit 6 and the displacement operation unit 7: the block for verifying whether the counterpart of a feature

10 point is found or whether the feature point has moved. Nevertheless, the same advantage as the foregoing one can be provided by the displacement operation unit 7.

Next, referring back to Fig. 1, a description will be made of acquisition of images showing different distortions,

15 which are derived from application of pressure to a subject, using the diagnostic ultrasound system in accordance with the present invention.

According to the present embodiment, the probe 1 is used to apply pressure during transmission or reception of

20 ultrasonic waves in order to produce images. Echo signals which are signals corresponding to echoes received by the transducers are sequentially transferred to the ultrasonic-wave transmitting/receiving unit 2. After the echo signals are phased and added up, a resultant signal is transmitted

25 to the complex cine memory 3. In the complex cine memory 3,

a plurality of frames, that is, a plurality of cross-section images is time-sequentially stored together with their phase information. The stored cross-section images are sequentially outputted to each of the frame memory 4,

5   feature point sampling unit 6, and displacement operation unit 7.

The feature point sampling unit 6 compares an image read from the complex cine memory 3 with a pre-displacement image received from the displacement operation unit 7, and

10   extracts a feature point and its counterpart. The coordinates of the feature point and counterpart extracted by the feature point sampling unit 6 are outputted to the displacement operation unit 7. The image read from the complex cine memory 3 is deformed so that the feature point

15   and counterpart will be agreed with each other. The image that has been deformed and the image that is not deformed are compared with each other in order to calculate a variation of deformation. The variation of deformation is regarded as a displacement value. The displacement value is

20   compared with the maximum and minimum displacement values which are stored. Only when the displacement value exceeds the maximum value or is smaller than the minimum value, the maximum or minimum value is updated to the newly calculated displacement value. At this time, if the updated

25   displacement value were the minimum displacement value, the

previous initial image would be updated to the image in

which the feature point is seen to have been displaced to a

variation indicated with the minimum displacement value. On

the other hand, when the updated displacement value were the

5   maximum displacement value, the previous post-displacement

final image would be updated to the image in which the

feature point is seen to have been displaced to a variation

indicated with the maximum displacement value. The maximum

and minimum displacement values are transmitted as the

10   maximum and minimum displacement values indicating the

variations of displacements made by a region-of-interest to

the frame memory 4. The initial image is transmitted as an

image, in which the region-of-interest is seen to have been

displaced by a variation indicated with the minimum

15   displacement value, to the frame memory 4. Moreover, the

post-displacement final image is transmitted as an image, in

which the region-of-interest is seen to have been displaced

by a variation indicated with the maximum displacement value,

to the frame memory 4. Consequently, an image for

20   displaying is constructed according to a cross-section image

which is transmitted from both of the complex cine memory 3

and measured in real time, and a distortion image produced

based on the maximum and minimum displacement values

transmitted from the displacement operation unit 7 and the

25   initial image and post-displacement final image. The image

which is constructed for displaying is then displayed on the display area of the display unit 5.

For example, a difference image is produced based on the post-displacement final image and initial image
5 according to a known technique. The difference image is displayed as the distortion image together with a cross-section image, which is measured in real time, on the display unit 5.

The distortion image is, as shown in Fig. 13, displayed
10 in gray-scale in colors while superposed on a cross-section image. A plurality of region-of-interest ROI#1, ROI#2, ROI#3 is delineated as desired region-of-interest by use of the setting unit 30. Namely, the displacement values indicating the variations of displacements made by the
15 designated regions of interest ROI#1, ROI#2, and ROI#3 are displayed as shown in the right lower part of the drawing. Data representing a distortion image (a difference between cross-section images) are produced through arithmetic operations so as to display of the numerical values. For
20 example, a known character string generator converts the image data into characters, and the characters are displayed in the cells in a table allocated to ROI1, ROI2, and ROI3. Because the cross-section image and distortion image are measured in real time, an instantaneous value that updates
25 in real time is displayed. Instantaneous values may be

sequentially stored in a memory in order to calculate statistics including a cumulative value and an average, and the statistics may be displayed. The statistics including the cumulative value, average, variance, and standard

5   deviation may be calculated according to a known statistical data calculating method. Moreover, the number of statistics displayed may not be one, but a plurality of statistics, for example, the instantaneous value and average may be displayed in combination. Moreover, a macro displacement

10   that is a displacement made by a biological body may also be displayed.

        Moreover, instead of the numerical values shown in Fig. 13, or in combination with them, a graph shown in Fig. 14 may be displayed. For display of the graph, data

15   representing a distortion image (a difference between cross-section image data items) is calculated through arithmetic operations, and a known graph generator converts the calculated data into a graph that can be displayed in a desired display area on the display unit. The graph

20   produced is then displayed. Fig. 14A shows the relationship of displacements based on region-of-interest to the macro displacement based on a biological body. The graph makes it possible to verify at sight which of the region-of-interest exhibit local hardness. For example, in this example,

25   because the displacement based on the region-of-interest

ROI3 is small, it means that a part of the region-of-

interest ROI#3 is hard and suspected of being a malignant

tumor. Consequently, the graph can provide a doctor with

diagnostic information signifying that close examination is

5   needed. Moreover, as shown in Fig. 14B, a bar graph

permitting comparison of displacements made by regions of

interest may be adopted. Even the bar graph can provide a

doctor with diagnostic information similar to the one shown

in Fig. 4a. Incidentally, aside from the bar graph, any of

10   various graphs including a line graph, a solid bar graph,

and a solid line graph, and a circular graph may be adopted.

     Various display forms are conceivable. Namely, region-

of-interest may be displayed in different manners, that is,

in different colors or shapes. A locus of points indicating

15   the position of an image attained before application of

pressure and the positions of the image displaced after

application of pressure may be displayed. The images

produced before and after application of pressure may be

displayed in different colors. One of the images produced

20   before and after application of pressure may be displayed

with a solid line and the other may be displayed with a

dashed line. The images produced before and after

application of pressure may be displayed while being

superposed on each other. The images produced before and

25   after application of pressure may be displayed side by side.

Any of the display forms may be adopted independently or in combination.

Thus, a portion of an image showing different hardness can be displayed while being clearly distinguished from the other portion. Moreover, a distortion image can be produced without the necessity of a special stress application device. Wherein, the maximum and minimum displacement values and the distortion image may be displayed together with a cross-section image sent from the complex cine memory 3, that is, a real-time cross-section image. Alternatively, the maximum and minimum displacement values and the distortion image may be displayed after acquisition of cross-section images is completed or responsively to handling of the setting unit 30.

As mentioned above, in the diagnostic ultrasound system of the present embodiment, the probe 1 is used to directly give a pressure to a region-of-interest. The displacement operation unit 7 uses cross-section images, which are sequentially measured, to calculate the maximum and minimum displacement values, which indicate maximum and minimum displacements made by a region-of-interest, in real time. Any special application device is unnecessary, and the time required for application of pressure is saved. Consequently, the time required for diagnosis is shortened. Eventually, a load incurred by an examining physician or a subject can be minimized.

Moreover, because an examining physician need not make
a subjective judgment, objective ultrasonic examination can
be achieved. Consequently, the time required for
examination will become even despite a difference in
5   experience in ultrasonic examination.

Fig. 2 is an explanatory diagram schematically showing
the configuration of the feature point sampling unit
included in the present embodiment. As apparent from Fig. 2,
the feature point sampling unit 6 included in the present
10   embodiment comprises: a first filter 8; a power calculation
block 9 electrically connected to the first filter 8; a
weighting block 10 electrically connected to the power
calculation block 9; a clustering block 11 electrically
connected to the weighting block 10; a correlation pre-
15   processing block 12 electrically connected to each of the
first filter 8 and clustering block 11A cross-correlation
block 13 electrically connected to each of the correlation
pre-processing block 12 and a second filter 15; a
counterpart calculation block 14 electrically connected to
20   the cross-correlation block 13; and the second filter 15
electrically connected to the displacement operation unit 7.

Referring to Fig. 2, the first filter 8 is a known
filter that selectively passes image data which represents
certain spatial frequencies and which is read from the
25   complex cine memory 3. According to the present embodiment,

the first filter 8 offers, as shown in Fig. 9, a passband in the form of a concentric circle with a spatial frequency of 0 as a center point. Fig. 10 is an explanatory diagram concerning the passband shown in Fig. 9. As apparent from

5   Fig. 10, the first filter 8 included in the present embodiment is a bandpass filter that has a lower-limit cutoff frequency set to about $\pi/16$ and has an upper-limit cutoff frequency set to a range from about $\pi/4$ to $\pi/2$.

The power calculation block 9 is a means for

10   calculating the powers of image data sent from the first filter 8. As shown in Fig. 3, the sum of the squares of data items at all points P(x, y) within a circle having a radius r with a point concerned O(x, y) as a center thereof is calculated as the power of data at the point O. The

15   power calculation unit 9 performs this calculation on every point (x, y).

The weighting block 10 is an operation means for applying a predetermined weight to the distribution of powers calculated by the power calculation block 9. The

20   weight to be applied is, for example, as shown in Fig. 4, increased toward to a sideways center, and is decreased toward a lengthways center.

The clustering block 11 is a means for detecting two peak points in the distribution of powers sent from the

25   weighting block 10, and retrieving values associated with

the peak points. For example, as shown in Fig. 5, the

coordinates (x1, y1) of the largest peak point and the

associated value Q1 are retrieved as the first data, and the

coordinates (x2, y2) of the second largest peak point and

5   the associated value Q2 are retrieved as the second data. A

known propagation deletion method or the like may be adopted

as a method of separating or identifying a peak point from a

two-dimensional distribution having a plurality of peak

points.

10   The correlation pre-processing block 12 is a means for

fitting a predetermined weighting function to the

coordinates of the two peak points and the associated values

that are detected by the clustering block 11. For example,

when a Gauss' curve expressing a Gaussian distribution is

15   adopted as the graph of the weighting function, the

weighting function is applied so that a Gaussian

distribution expressing a standard deviation of 3σ will be

produced to have each of the two peak points Q1(x1, y1) and

Q2(x2, y2), which are associated with the values Q1 and Q2,

20   as a center thereof. However, the weighting function is not

limited to the Gauss' curve expressing the Gaussian

distribution. Alternatively, the Hamming window function,

Hanning window function, or Blackman-Harris window function

will do.

25   The cross-correlation block 13 is a known means for

calculating correlations between the distribution of weights sent from the correlation pre-processing block 12 and image data sent from the second filter 15.

The counterpart calculation block 14 searches a

5 distribution of correlations received from the cross-correlation block 13 for two peak points and their associated values. The counterpart calculation block 14 performs arithmetic operations similar to those performed by the clustering block 11. As a result of the arithmetic

10 operations performed by the counterpart calculation block 14 included in the present embodiment, for example, as shown in Fig. 7, the coordinates (x3, y3) and (x4, y4) representing the two peak points and the values Q3 and Q4 associated therewith are determined.

15 The second filter 15 is a means for selectively passing joint image data that represents certain spatial frequencies and is sent from the displacement operation unit 7. The second filter 15 performs processing similar to the one performed by the first filter 8.

20 Next, actions to be performed by the feature point sampling unit 6 included in the present embodiment will be described in conjunction with Fig. 2.

The first filter 8 selectively passes image data that is carried by a signal sent from the complex cine memory 3

25 and that represents certain spatial frequencies.

Specifically, image data representing spatial frequencies ranging from $\pi/16$ to a range from $\pi/4$ to $\pi/2$ is sampled and transmitted to the power calculation block 9. The power calculation block 9 handles the received image data so as to

5   calculate the sum of the squares of data items at all points $P(x, y)$ within a circle having a radius r with respect to each of points concerned $O(x, y)$. The calculated sums are transmitted as the powers of the data at all the points concerned O to the weighting block 10. The weighting unit

10   10 serves as an operation means for applying a predetermined weight to data representing the powers. At this time, the weight to be applied will be increased toward the sideways center of the data, and decreased toward the lengthways center of the data. The resultant data are transmitted to

15   the clustering unit 11. The data received by the clustering unit 11 are subjected to, for example, known propagation deletion so that the coordinates of the two peak points and the associated values thereof will be detected. The detected coordinates and values are transmitted to the

20   correlation pre-processing unit 12.

The correlation pre-processing unit 12 also receives an output of the first filter 8. The coordinates of the two peak points and the associated values thereof which are detected by the clustering block 11 are weighted according

25   to the predetermined weighting function. The resultant data

is transmitted to the cross-correlation block 13. The cross-correlation block 12 calculates correlations (or a distribution of correlation values) of the received data with image data sent from the second filter, and transmits

5   the distribution of correlations to the counterpart detection block 14. The counterpart detection block 14 having received the distribution of correlations performs arithmetic operations similar to those performed by the clustering block 11 so as to detect the coordinates of two

10 peak points and the associated values thereof. Consequently, the coordinates (x3, y3) and (x4, y4) of the two peak points and the values Q3 and Q4 thereof are transmitted to the displacement operation unit 7.

Fig. 8 is an explanatory diagram schematically showing

15 the configuration of the displacement operation unit included in the present embodiment.

As apparent from Fig. 8, the displacement operation unit 7 included in the present embodiment comprises a deformation arithmetic block 16, a maximum deformation image

20 storage block 17, a minimum deformation image storage block 18, a final image storage block 19, an initial image storage block 20, and a distortion image operation block 21.

Referring to Fig. 8, the deformation arithmetic block 16 is a means for calculating as data signals distance

25 between a feature point and a counterpart which are

associated with each other by the counterpart calculation block 14 and a direction of movement made by the feature point.

The maximum deformation image storage block 17 is a
5 means for identifying and storing beam data signals of an image in which the feature points is seen to have deformed to the greatest extent.

The minimum deformation image storage block 18 is a means for identifying and storing beam data signals of an
10 image in which a distance between feature points including codes is smallest.

The final image storage block 19 is a means for storing an image in which a change of the feature points is greatest. The stored image is transmitted to the distortion image
15 operation block 21.

The initial image storage block 20 is a means in which an initial image is updated with data (image data) identified by the minimum deformation storage block 18, and stored as new initial image data. The stored image data is
20 transmitted to each of the feature point sampling unit 6, deformation arithmetic block 16, and distortion image operation block 21.

The distortion image operation block 21 is a means for visualizing the displacement (distortion) made by a
25 biological tissue using the images in which the feature

point is seen to have been distorted to the variations

indicated with the maximum and minimum displacement values.

As mentioned above, the displacement operation unit 7

calculates a distance between a feature point and its

5   counterpart that are associated with each other by the

counterpart calculation block 14 on the basis of the

coordinates of two pairs of peak points and the associated

values thereof (distributions of powers). Thus, the largest

and smallest distances are detected.

10   Moreover, aside from the foregoing hardware

configuration, a computer included in the diagnostic

ultrasound system may be used to implement a method of time-

displaying displacements made by a biological tissue.

Namely, displacement values indicating displacements made by

15   a biological tissue of a subject are time-sequentially

stored in a storage means, and time-sequentially read from

the storage means in order to visualize the displacement

values relatively.

When many patients are examined during, for example,

20   mass screening, the diagnostic ultrasound system is used to

measure and store a plurality of cross-section images before

and after each of the subjects is pressed using the probe.

Thereafter, the plurality of stored cross-section images is

used to calculate and display displacement values.

25   Measurement of displacement values and diagnosis can be

performed independently of each other in a concentrated

manner. Consequently, an efficient observation environment

can be provided.

Fig. 15 describes a concrete procedure for implementing

5   a distortion displaying method.

<Producing a first image> Ultrasonic measurement is

performed with the probe touched to a subject in a first

state in order to produce a first image of the subject (Step

151).

10   <Delineating a region to be observed> A region to be

observed (reference information) is delineated in the

produced first image (Step 152). The delineation falls into

manual delineation in which a region to be observed is

delineated in an image displayed on the display screen, and

15   automatic delineation in which a region in which a distance

to a feature point (macro distance) is equal to or larger

than a specified value is delineated as a region to be

observed. When the automatic delineation technique is

adopted, the first image produced by the first image

20   production means is displayed on the image display means,

and at least one region-of-interest is delineated in the

first image.

When the densities of portions of an image are

different from each other, for example, when an image shows

25   a normal tissue and an abnormal tissue, a region supposed to

be the abnormal tissue and identified with the density is
sampled as a feature point, and the sampled feature point
and its surroundings are designated as a region-of-interest.

<Producing a second image> Ultrasonic measurement is
5   performed with the probe touched to the subject in a second
state different from the first state in order to produce a
second image of the subject (Step 153).

<Calculating a change> A change of the coordinates of
an observation point in the second image from the
10 coordinates of a counterpart in the first image is
calculated (Step 154).

<Calculating a distortion> A distortion made by a
desired region-of-interest is calculated based on the
calculated change (Step 155).

15 <Displaying an image> The calculated distortion
information is displayed (Step 156). The Step 153 and
subsequent steps may be repeated in order to display a time-
sequentially varying second image. The display form has
been described previously.

20 Moreover, the present invention may be implemented in a
program for displaying displacements, which are made by a
biological tissue, together with an ultrasonic image. In
this case, the program is installed in a computer system
comprising an input unit that includes a known keyboard, a
25 known mouse, and an interface via which data is received

from the diagnostic ultrasound system, a processing unit such as a processor that acts according to a program, and an output unit that includes a monitor on which an image is displayed according to the result of processing.

5 Displacement values indicating displacements made of a biological tissue of a subject are time-sequentially stored in a storage means, and time-sequentially read from the storage means in order to calculate distortion information from the displacement values.

10 Consequently, when a personal computer owned by an examining physician or a paramedic is adopted as the computer system, the foregoing displaying method can be implemented. Moreover, a program capable of editing the results of diagnosis may be used to produce electronic

15 clinical recordings. Moreover, when the personal computer supports a network environment, secondary utilization of data is enabled, for example, diagnostic information may be provided for individual patients. Wherein, because diagnostic information is personal information that is

20 ranked as a top secret, preferably the information is protected with a perfect security facility.

The invention made by the present inventor has been described in conjunction with the embodiment. The present invention is not limited to the embodiment but may be

25 modified in various manners without a departure from the

gist thereof.

The present invention provides an advantage that ultrasonic images are time-sequentially acquired by varying the pressure imposed on the probe, and the softness or hardness of a biological tissue is visualized using a difference between ultrasonic images.